SERVICE DOES NOT REQUIRE BIG SPECTRUM

CDMA TDMA AMPS

2.5 MHz = 7.5 MHz = 25 MHz

Thus, in 20 MHz block to equal total cellular capacity:

12.5 percent CDMA

37 percent TDMA

POLICY CONCLUSIONS

- No need for a technology-based "adjustment"
  - 800 MHz and 2 GHz functionally equivalent
- Solving the "incumbency problem"
  - Back-end solution: large spectrum blocks
  - Front-end solution: facilitate rapid clearing
- Advantages of front-end solution
  - Spectrum efficiency
  - Rapid deployment
  - Maximum opportunity
  - Maximum competition

POLICY CONCLUSIONS (CONTINUED)

- Instead of big blocks, encourage clearing of reasonably-sized blocks
  - Use tax certificates aggressively
    - Tie tax certificates to voluntary movement only
    - Value of tax certificate decreases with time
  - Discourage foot-dragging
    - Compensation only if move is within 90 days of being offered

RHETORIC V. ACTIONS

PCS Order provides "only" 10 MHz in the "worst" spectrum bloc with the greatest "microwave interference"

Yet, cellular industry is

- **Not saying 10 MHz is too little**
- **Not saying others shouldn't aggregate spectrum**
- **Not saying technical characteristics are no good**
- **Not saying microwave is debilitating**

Give us the tools

- **To develop new vertical services**
- **To grow out of core business (like the others)**
- **To do more than "more voice"**
- **To move from POTS to PANS**

Building The
Wireless Future

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Industry Association
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Randall S. Coleman
Vice President for
Regulatory Policy and Law

April 22, 1994

Mr. Ralph Haller
Chief, Private Radio Bureau and
Chairman of PCS Task Force
Federal Communications Commission
2025 M Street, N.W. - Room 5002
Washington, D.C. 20554

RE: Personal Communications Services - Docket 90-314

Dear Mr. Haller:

This letter is in response to the March 24, 1994, presentation of PCS Action to the members of the FCC's PCS Task Force, which was recently listed in the ex parte file for this docket.

Based on the summary of the PCS Action presentation, and the attachments thereto, it is necessary for CTIA to offer the following observations.

Interference Is Not A Problem

The arguments PCS Action advanced on behalf of 30 MHz spectrum blocks (and against 20 MHz blocks) are inconsistent with the facts developed in the PCS rulemaking record, and incompatible with the FCC's objectives and statutory mandates.

Specifically, PCS Action: (1) makes the specious assumption that a single PCS model exists, that can be foreseen and achieved by gerrymandering the spectral landscape; and (2) repeats the misleading *and already refuted* assertion that 20 MHz blocks are barred by existing microwave paths.

To the contrary, CTIA's August 25, 1993, PCS White Paper, and GTE's August 17, 1993, Comsearch study of Detroit, demonstrate that minimal interference exists when valid power and technology assumptions are used, and that such interference is readily remedied by path relocations. (*See* attached copy of CTIA's August 25 *PCS White Paper*, at pp. 2 and 5.)

In fact, standard engineering practices -- good engineering -- would be used to engineer a PCS system. Thus, for example, you would engineer a PCS base station by placing PCS antennas on different radiation planes, outside the path (or beamwidth) of a microwave system. Also, orthogonal polarization would be a primary engineering consideration.

The August 1993 White Paper on "Sharing Spectrum Between PCS and Microwave Systems," prepared by Dr. Charles L. Jackson and Professor Raymond L. Pickholz, and filed in this docket by Bell Atlantic Personal Communications on August 24, 1993, noted the deviation of the PCS Action/APC study assumptions from such common engineering practices. *See* Jackson and Pickholz White Paper at pp.6-10, attached.

The Commission must also appreciate that allegations of a short-term interference problem cannot justify the long-term sacrifice of a limited public resource, the spectrum.

The PCS Action graphics which *appear to* demonstrate that 25 percent, 50 percent, and 75 percent of the allocated spectrum will be needed in the third, fifth and tenth years of operation simply present assumptions, not facts. They do *not* reflect the spectrum actually available, nor required for initial operations. This is understandable. As Dr. Irwin Jacobs of Qualcomm observed in last week's PCS Task Force hearing, "*the main issue is **not** going to be using all your bandwidth. You're not going to have enough customers to do that. So you're going to have to clear out a small amount of bandwidth. You're probably not going to use even 10 MHz; you're going to use the smaller part to get started.*" *See* Transcript of FCC En Banc Meeting on PCS Issues, Tuesday, April 12, 1994, at p.117.

Graphic illustrations of the worst-case presence of microwave paths (such as in Southern California) are irrelevant to the Commission's obligations to ensure the efficient use of spectrum, and to the practices which will ensure PCS viability. As Cox Enterprises' cable-based PCS plans for Southern California indicate, providers *will* engineer their systems to minimize interference, and arrange for efficient microwave relocation, even in the worst-case markets. *See* Cox Enterprises Application for an Initial Authorization in the Personal Communications Service, Los Angeles-San Diego, California, MTA, filed March 31, 1994, at Exhibit 5, pp.14-15 (use of cable height antennae reduces potential interference with microwave paths, and reduces the cost of microwave relocation by almost 75 percent).

Spectrum Clearing Will Proceed Apace

In fact, the spectrum-clearing requirement will ensure that all of this spectrum will be available within the period when PCS Action's projected demand is hypothetically realized.

And PCS Action's assumptions about the recalcitrance of microwave licensees are contradicted by the experience of their own members -- American Personal Communications (APC) having worked closely with Baltimore Gas & Electric (BG&E) in their PCS trials.

As the attached letter from BG&E executive G.A. Dieter to APC President Albert Grimes, which was submitted to the FCC as Appendix V of APC's Seventh Progress report, on April 28, 1992, makes clear *"BG&E believes its 2 GHz fixed radio frequencies represent a marketable commodity that it is willing to sell or share in some mutually financially beneficial arrangement with a PCS developer and to do so in a foreshortened time frame well ahead of the*

proposed 5-15 year period suggested by the FCC." Letter from G.A. Dieter, Supervisor Planning & Development Unit Telecommunications Department, BG&E, to Albert Grimes, APC President, dated April 9, 1992.

Indeed, utility awareness of the challenges and opportunities posed by PCS is by no means limited to BG&E. As the attached article, "Information Superhighways are Under Construction at Many Electric Utilities," from the February 1994 issue of *Electrical World* demonstrates, utilities have already identified the opportunities in updating their networks, and in providing elements of the national information infrastructure.

Utilities have already begun shifting from the 2 GHz band to the 6 GHz band, according to Tampa Electric Co. (TECO) spokesman Gregg Ehlers. TECO, and other utilities, have begun deploying facilities such as fiber rings and backbone networks in order to lease space to "PCS providers 'and anyone else who needs it for communications services,'" to quote Mr. Ehlers.

As *TR Wireless News* recently reported, these opportunities were underscored at the March 17, 1994 Comsearch/PCIA microwave relocation conference, at which Jeffrey L. Sheldon, General Counsel for the Utilities Telecommunications Counsel (UTC), declared that:

> Many incumbent utility microwave licensees can bring a number of services to the negotiating table that would benefit start-up PCS companies. For example, . . . utilities have (1) towers, poles, and rights of way for cell-site deployment; (2) cell-site interconnect service based on fiber optic or microwave technology; (3) customer billing for virtually the entire market population; (4) customer service centers; (5) engineering and construction services; (6) facilities management; (7) access to capital markets; and (8) corporate name recognition.

TR Wireless News, March 24, 1994, at p.7.

Moreover, contrary to PCS Action's assertions and graphics, the spectrum clearing period will ensure that -- even by their own overly-pessimistic assumptions -- *sufficient spectrum will be available in a timely fashion for PCS services to be delivered using the new spectrum allocation.*

As the *Memorandum Opinion and Order* in ET Docket No. 92-9, released March 31, 1994, clearly indicates, holders of microwave licenses have both incentives to deal and penalties for obstructive behavior: "[T]he Commission has a number of means to discourage [unreasonable refusal to enter into relocation agreements] when a request for mandatory relocation is before it. For example, in an egregious case of non-cooperation we could consider requiring the emerging technology provider to pay less than the full cost of relocation, or even none of the cost. Inasmuch as when a case is referred to us for decision the total agreement would be subject to our decision, we believe parties have a clear incentive to voluntarily reach reasonable agreements." *Memorandum Opinion and Order*, ET Docket No. 92-9, FCC 94-60, released March 31, 1994, at n.44.

Goodstadt Study Argues for Market Share Allocation

The Goodstadt study assumes a zero sum game (perfect substitutability) between "cellular" and "PCS." As total wireless subscriptions under their projections are about 55 million by 2005 -- whether or not PCS is implemented in 1997 or 1998 -- it appears what they are arguing for is allocation of market share between players denominated "cellular" and "PCS."

What is at stake in the Goodstadt study seems to be whether PCS will amount to 22 percent or 26 percent of the total wireless market in the year 2005 (depending on whether PCS is implemented in 1997 or 1998) -- whether it reaches 17 million customers within ten years of introduction, or 14.5 million within nine years, or 12 million within eight years. Given that cellular itself out-performed every long-term demand forecast as it set the record for growth in high technology services by reaching 11 million customers in ten years, it seems absurd to debate the prospective market share "PCS" may reach in the 21st century.

In fact, an underlying implication of the presentation slide is that cellular companies intend to delay the introduction of PCS, something contradicted by both the rulemaking record and the commitment to PCS roll-out cellular companies have shown in their PCS trials -- and the Goodstadt forecast that shows roughly the same number of *total* customers for the *same* PCS/cellular service.

The Conifer Group - Auctions and the Unknown

The Conifer Group's presentation slides essentially argue that the results of auctions are unknowable -- and that the results of secondary market transactions are unknowable. From this rather admirable agnosticism, they leap to the assertion that the auction process should be used to try to fix the results according to their own assumption that large spectrum blocks are the most efficient.

In fact, *the thesis that award of large blocks will be more efficient than smaller blocks, and that aggregation of smaller blocks "may not be . . . fixable in the secondary market" inverts reality*. The award of large blocks may result in effectively warehousing spectrum, for which no remedy exists other than the extremity of governmental recapture. If the Commission starts with big blocks, and errs by making the allocation too big, the market cannot correct the mistake. If the Commission starts with the award of smaller blocks, and errs by making allocation too small, the market can correct the sizing of allocations through aggregation.

In fact, *no one and certain model of PCS services exists*. There are many visions of PCS, and many providers willing and eager to bid for the resources to realize those visions. *The Commission should not accept the notion that one single vision should be favored above all others, nor should it preserve such a wasteful proposition as 30 MHz spectrum blocks as a pre-auction predicate.*

The future is unknowable, and the results of both auctions and the operations of the telecommunications marketplace are unknown. *The Commission should therefore adopt a flexible policy which permits the superior discovery mechanism of the marketplace, and the preferences of customers, to drive the formation of PCS services and the selection of winners and users* -- rather than trying to adopt a structure which attempts to allocate and freeze market share.

Conclusion

A policy which presumes a single vision of PCS, and requires 30 MHz to deliver it, is doomed to failure, for it both contravenes the Commission's mandate to foster diversity in the wireless industry (as 30 MHz blocks are *not* compatible with growth opportunities for both large and small players), and compromises its policy of fostering efficiency and innovation in spectrum-based services.

Building blocks of 10 MHz and 20 MHz are superior to 30 MHz blocks as a starting point for the auction process, and will not delay the deployment of PCS.

Very truly yours,

Randall S. Coleman

cc: FCC PCS Task Force
Chairman Reed Hundt
Commissioner James Quello
Commissioner Andrew Barrett
Karen Brinkmann

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Building The
Wireless Future

PCS WHITE PAPER No. 3

TITLE:

Justifying 40MHz PCS Allocations: 'Study' Was Based on Invalid Assumptions

August 25, 1993

Justifying 40MHz PCS Allocations: 'Study' Was Based on Invalid Assumptions

Invalid Conclusions Based on False Assumptions

As recently as August 24, the American Personal Communications-Washington Post partnership stated in a letter to FCC officials:

> By now it has been *demonstrated beyond doubt* that ... PCS needs large spectrum blocks, particularly in major markets...[emphasis added]

The PCS Action, Inc., "White Paper on Spectrum Issues" similarly observed:

> The need for a sufficient [40MHz] amount of spectrum to permit PCS to be implemented in a shared environment is simply a *scientific fact of life* PCS licensees and the Commission must face. [emphasis added]

These assertions are principally predicated on an April, 1993 Comsearch study commissioned to "prove" spectrum crowding as a rationale for large spectrum allocations. This study was based on assumptions which deliberately magnified the potential interference problem and, thus, produced misleading conclusions:

- Power levels in the tests were in excess of permitted safety levels and 10 times the average power output projected for PCS.

- A worst-case technology was "utilized" instead of using an existing technology such as CDMA.

When Comsearch was asked to re-run the exact same study, but with valid assumptions -- based on real-world power levels and technology -- the amount of microwave interference virtually disappeared (see next page).

Original Study With Misleading Assumptions

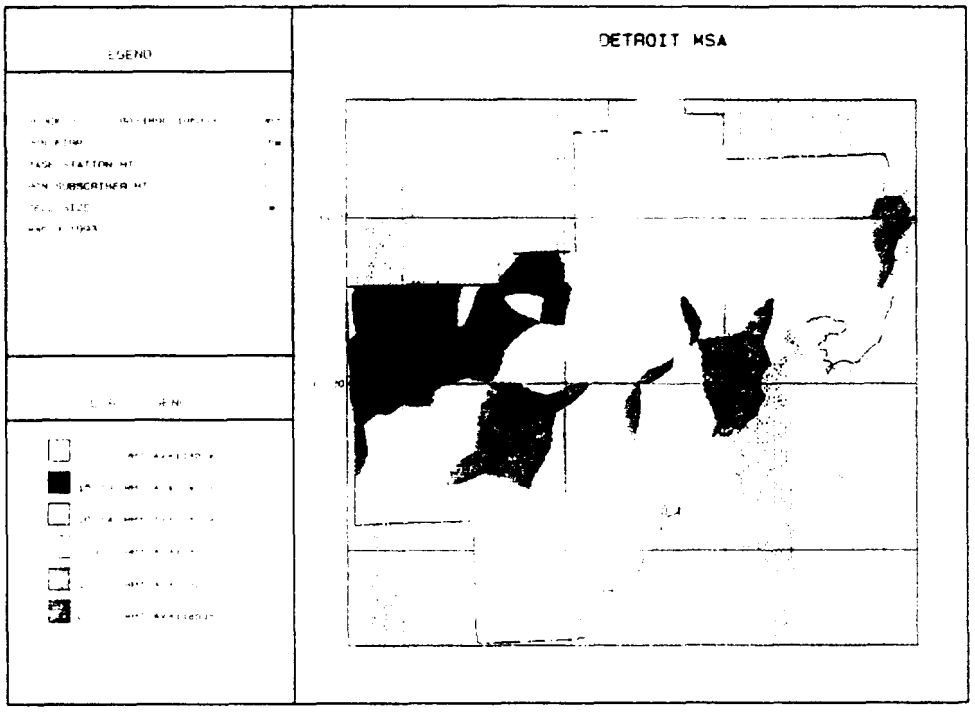

Figure 4.1-1 20 MHz Allocation. Block D. Current Spectrum Availability

Same Data Re-run With Valid Assumptions

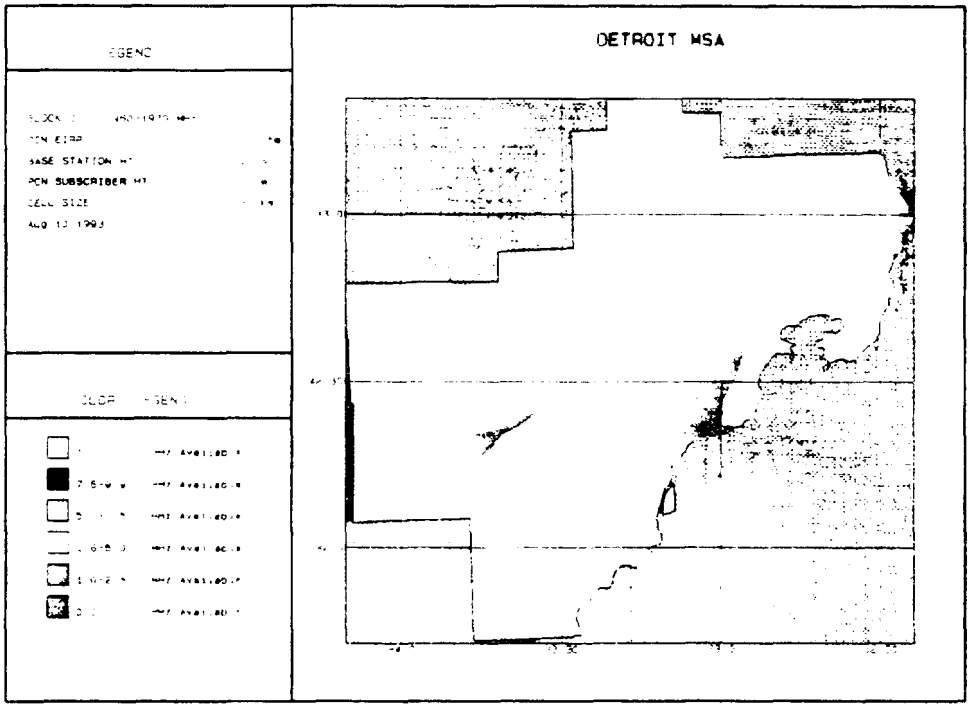

Figure 3.2-7 20 MHz - Block D (1960-1970 MHz) Current Spectrum Available COMSEARCH

The Answer Depends on the Question

In April, 1993 Comsearch produced a study of the Detroit area which supposedly identified where the spectrum available to PCS operators would be limited in order to protect existing microwave systems.[1] The PCS Action, Inc. Spectrum White Paper concludes, "Comsearch ... has found that a 20MHz PCS allocation would require 100 percent of public safety licenses and 50 percent of all licensees to be relocated during the first three years after PCS licensing." This conclusion is only as valid as the study upon which it was based, *a study in which it has now been revealed that the assumptions were manipulated to produce the desired result.*

Misleading Assumption #1 -- Power Level: The April Comsearch study assumed a 1.0 watt output from the PCS unit. This power level is:

- More than three times the permissible .3 watt safety level for 2GHz,[2]
- Five times the .2 watt peak power generally assumed for PCS,
- Ten times the .1 watt average power for PCS[3]

By overstating the PCS unit's power output, the study overstates the interference potential.

Misleading Assumption #2 -- Technology: The April Comsearch study assumed a time division duplex (TDD) architecture for PCS using a time division multiple access with eight slots on 200KHz. This is neither the North American digital IS-54 standard nor the GSM-based DCS 1800 European standard.

In fact, because of the frequency offsets utilized by the microwave transmissions, the use of a TDD assumption exacerbates the interference problem. In a previous filing, for instance, American Personal Communications (a strong and vocal proponent of the April Comsearch study,) told the Commission that based on its operational experience with both TDD and frequency division duplex (FDD):

> On balance, APC believes that the PCS allocation structure must allow for an FDD architecture ... the advantages of a TDD architecture are outweighed by the advantages of an FDD architecture.[4]

---

[1] See, Spectrum Allocations and Their Impact on Microwave Use Relocation: A Case Study," Comsearch, April, 1993.

[2] See, IEEE "Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3KHz to 300GHz", IEEE (95 1-1991, April 27, 1992, p. 18

[3] See, Qualcomm Incorporated, Quarterly Progress Report for Personal Communications Service, File Number 2345-Ex-PL91, filed July 19, 1993, p 4-4, figures 4-11 to 4-13.

[4] See, "Report on Spectrum Availability for Personal Communications Services Sharing the 1850-1990 MHz Band with the Private Operational Fixed Microwave Services," American Personal Communications, November, 1992.

By utilizing a technology already found to increase interference, the study overstates the interference potential.

Redoing the Study -- The Right Way

Utilizing exactly the same data as the April study, Comsearch was commissioned to re-run its analysis, but this time, with legitimate assumptions as to technology and power. The new August Comsearch study utilized code division multiple access (CDMA) technology (i.e., the kind of FDD technology specifically cited in the November APC filing as preferable). The August study also utilized the maximum allowable power of .3 watt (which, itself, is approximately three times the average power output forecast for a PCS unit).

The result of utilizing proper assumptions is illustrated on page two of this White Paper. What, under faulty assumptions, appeared to be an insurmountable interference problem is, in reality, a minimal, very manageable situation. By moving only three microwave paths, for instance, the exclusion areas totally disappear (see next page).

Interference Areas
With Valid Assumptions -- Moving No Microwave Paths

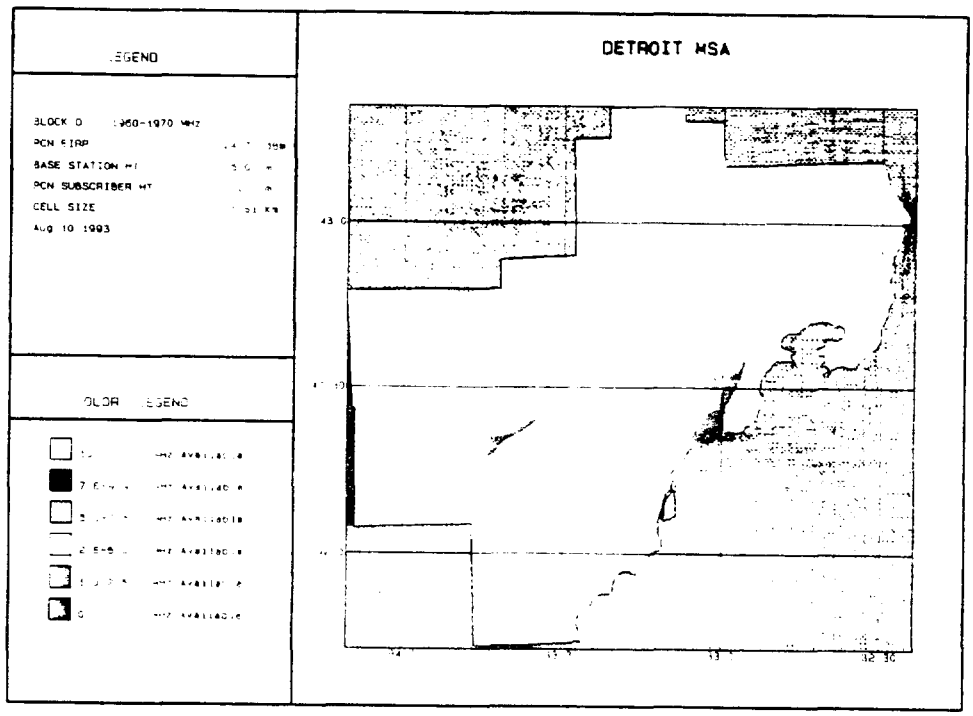

Figure 3.2-7 20 MHz - Block D (1960-1970 MHz) Current Spectrum Available COMSEARCH

With Valid Assumptions -- Moving Only Three Microwave Paths

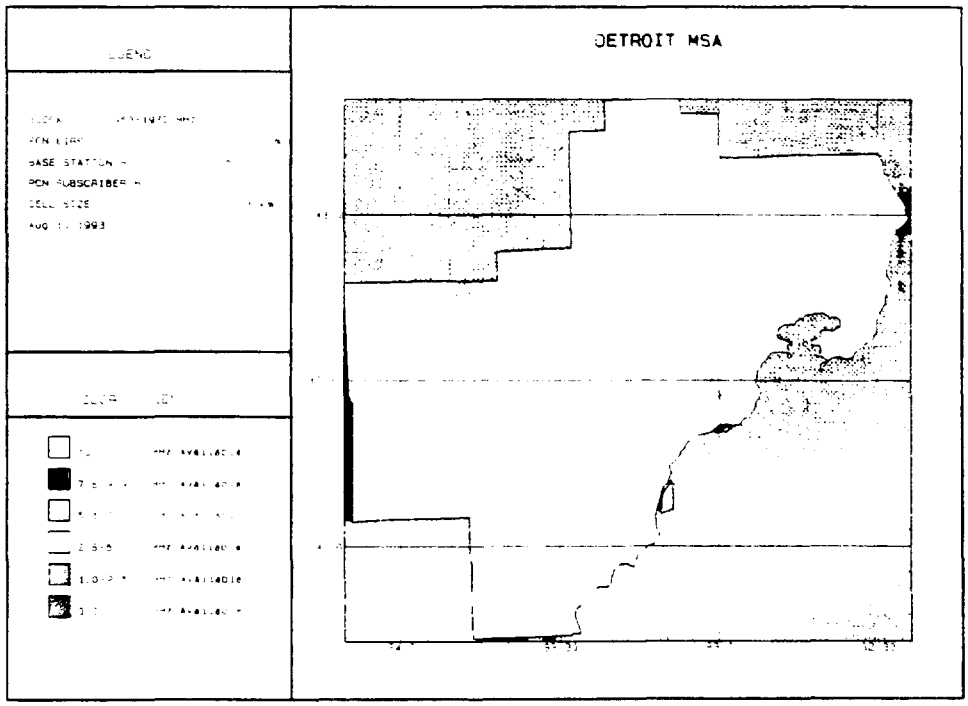

Figure 3.2-8 20 MHz - Block D (1960-1970 MHz) 3 Paths Removed, (7.5 MHz Available) COMSEARCH

Warehousing Large Amounts of Spectrum Precludes Opportunities

The cellular industry's often stated concern about 40MHz spectrum allocations has been repeatedly dismissed and characterized by the large spectrum advocates as "merely attempting to prevent PCS from reaching its full potential."[5]

Other than the concern that the "facts" presented to the FCC have been manipulated to produce an invalid conclusion, the cellular industry's problem with 40MHz licenses is that *it precludes opportunity for many* (including cellular operators) by locking up excess spectrum capacity in the hands of a few.

Because of their size, 40MHz blocks eat up the available PCS spectrum in a few big bites. Such big bites (now called "big PCS" by its proponents) makes an overly large spectrum grant to two parties, thus eliminating opportunities for others and encouraging the inefficient use of spectrum.

PCS applicants should be permitted to aggregate two 20MHz blocs if, in fact, 40MHz is essential in a particular situation. But, the Commission should not establish 40MHz blocs as the basic PCS building blocks, when there is no proven need either technically (i.e., the August Comsearch study) or economically (20MHz of spectrum utilizing CDMA has eight times the capacity of 25MHz of analog cellular).

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[5] See, "White Paper on PCS Spectrum Issues," PCS Action, Inc., July 21, 1993, p.1.

Sharing Spectrum Between PCS and Microwave Systems

by
Dr. Charles L. Jackson and Professor Raymond L. Pickholtz

August 1993

The principal objective of the April 1993 Comsearch Study was to estimate the extent of any OFS relocations that would be necessary if no engineering were done to the PCS system to mitigate interference. The assumptions were not intended to be definitive and the conclusions, then, have meaning only in relative terms. Thus, all other things being equal, an operator with 40 MHz of spectrum could initiate operation with less need to engineer around or to relocate OFS users than would an operator with 20 MHz. However, the use of improved technology, like low-power CDMA, greater antenna isolation, and proper base station engineering, can make up the difference and result in more efficient bandsharing.

IV Appraisal of the APC Studies and the April 1993 Comsearch Study

Both the APC studies and the Comsearch study appear to be appropriate for their original intended purposes, but they are not appropriate for a detailed understanding of PCS/microwave spectrum sharing. Our analysis below focuses on the Comsearch study since it was prepared more recently and represents a more complete analysis. Nonetheless, most of our comments apply as well to both studies. While both the APC and Comsearch studies provided useful information to the Commission, they are potentially misleading in two major respects:

(1) The technological assumptions are excessively conservative and unwarranted; and

(2) The geographic areas identified in those studies as having no spectrum available for PCS should not have been so identified. Rather, they should have been identified as areas where more detailed analysis of spectrum sharing was required or where careful engineering of the PCS system was required to permit sharing.

Overly Conservative Assumptions of These Studies

Power level

Both APC and Comsearch assumed that a PCS portable unit would operate at one watt power.[10] This is higher than the power level at which cellular portables operate today, and is far higher than expected for PCS systems. For example, Qualcomm has reported reliable PCS operations to the Commission with average powers around one milliwatt.[11] Changing this one parameter would significantly reduce PCS interference into microwave systems. Numerous other assumptions in these studies are similarly conservative.

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[10] *See* 1991 APC Study at 17; April 1993 Comsearch Study at § 3.3.

[11] Qualcomm Incorporated, Quarterly Progress Report for Personal Communications Services, File No. 2345-EX-PL91 (July 19, 1993), at 4-4 and figs. 4-11 to 4-13.

We have identified in the April 1993 Comsearch Study the following significant assumptions that increase the calculated size of the so-called "exclusion zones" beyond what would be expected:

- Peak power of one watt (30 dBm) on mobile.

- Use of peak rather than average power.

- Use of the Hata propagation model without considering actual terrain or building blockage of paths.

- Interference calculations that assume that the subject microwave system is a fully loaded analog FM system, rather than using actual loading.

- Use of the older EIA TSB-10E interference standard, rather than the proposed EIA TSB-10F standard, which allows for a more realistic "availability" measure of interference.

- No consideration of the elevation effects on the directional pattern of the microwave receive antenna.

- No correction for cross-polarization rejection of the microwave antenna.[12]

- No consideration of the fact that microwave fades at 2 GHz tend to occur during the night, while PCS activity will peak in the day.

- No consideration of the use of interference mitigation techniques in the design of the PCS system in the neighborhood of microwave receivers. Such considerations could consider:

a. Careful engineering of the location, antenna height and antenna coverage of the PCS base station,.

b. Null steering at PCS base stations.

c. Automatic power control near microwave receivers.

d. Upgraded antennas at microwave receivers.

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[12] "...[T]his would add 20 -30 dB interference protection to one-half of all OFS systems." 1991 APC Study, Vol. 1, at 28.

e. Upgrade of analog microwave systems to digital (this approach would allow reuse of antennas, feedlines and towers, but would increase the interference rejection capability of the system). Uncoded digital modulation would buy at least 10 dB of interference protection. Channel coding offers 5 to 6 dB more.

f. Adaptive, "smart" antennas at the base station, which minimize mobile power and interference to OFS.[13]

Implications of Overly Conservative Assumptions

Each of these conservative assumptions increases the calculated size of the "exclusion zones." More seriously, the APC studies and the April 1993 Comsearch Study use the somewhat misleading term "exclusion zone" to refer to areas where PCS operations, while circumscribed, are not excluded.[14] Let us us consider each of these assumptions in turn to understand the implications each has on the offered conclusions.

Peak power

Both the APC and Comsearch studies assumed that PCS mobile units would operate at one watt (+30 dbm). Current cellular portables operate at only 600 milliwatts; Qualcomm's 1800 MHz units have maximum power levels of less than 200 milliwatts; and CT-2 units operate with 10 milliwatts of power -- a hundred times less than APC and Comsearch assumed. Of the systems being seriously considered for use in PCS, only DCS-1800 operates with peak power levels as high as was assumed in these studies, but DCS-1800 is a TDMA system so that its average power is 250 mW. Furthermore, the proposed safe level for biohazards, extrapolated to 1900 MHz, is about 330 mW.[15] Therefore, the peak power assumed in these studies is probably too high by a factor of five.

Peak power versus average power

If PCS portables operate at the lowest possible power necessary for effective communications, battery life is enhanced and interference in the PCS system is reduced. For these and other reasons, most PCS system designs incorporate power control systems resulting in the average power transmitted by a mobile unit being far less than the peak power. For example,

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[13] Such "smart" antennas, which have been demonstrated by ArrayComm, San Jose, California and others, could also increase spectral efficiency using Space Division Multiple Access (SDMA).

[14] This terminology is corrected in the attached August 1993 Comsearch Study. *See infra* note 17.

[15] IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz, IEEE C95 1-1991 (April 27, 1992), at 18, line 7.

Qualcomm has reported to the Commission operation of CDMA PCS systems at average powers of the order of one milliwatt.[16]

Comsearch calculated its "exclusion zones" by identifying regions where the energy from PCS operations would not contribute to unacceptable interference at the microwave system. In doing so, Comsearch added up the interfering signals from hundreds of PCS interference sources. It is unreasonable and overly conservative to assume that all of these sources will be operating at peak power all of the time. However, properly combining the average levels is difficult and the overly conservative assumption simplified both the programming and the computational task. A compensation for this consisted in using the aggregate power on a peak basis for a uniform distribution and then computing interference based upon individual grid points.

Average interfering power will be far lower than the peak power used in the Comsearch analysis, and is a more appropriate parameter for looking at systems under interference. The recommendations in Annex H of bulletin 10 offer the refinement "system level power control must be factored in to determine the 'average operating power output' of the mobile units (and base stations where applicable) as a group."[17]

Hata model

Propagation from the PCS system to the microwave system was modeled by Comsearch using a modified Hata model. This model does not take into account any specific path blockage from terrain or buildings. Of course, such blockage is significant in urban areas and will reduce the interference to OFS. Again, incorporating buildings and terrain blockage into the Comsearch model would have substantially complicated the modeling task.

Assumption of a Fully-loaded FM system

The interference standard used in the study (EIA TSB-10E) assumes that the microwave system subject to interference is a fully-loaded system. Interference in such systems is worst for the highest channel and standards control such interference. Real-world systems are usually less than fully loaded and consequently are far more resistant to interference. Taking such loading into account is complex and is not a normal part of interference control calculations. Nevertheless, this hidden assumption biases the results against PCS operations.

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[16] *Op. Cit.*

[17] PCS/POFMS Microwave Spectrum Sharing Considerations (July 26, 1993), at 5 (sent to joint committee).

EIA 10E versus EIA 10F

The interference standard used in the analysis was the EIA 10E rather than the proposed EIA TSB-10F. TSB-10E does not take into account any extra link margin on short-range microwave systems. If a microwave radio link has a 50 dB fade margin, yet only requires a 35 dB fade margin to provide 99.999% availability, EIA 10E will permit only 1 dB of added interference into the microwave system rather than the 15 dB that would be consistent with maintaining the 99.999% availability. EIA is developing a new standard, 10F, which takes availability into account and better models real-world interference performance.

Elevation directional effects

The April 1993 Comsearch Study did not fully take into account the directional pattern of the microwave receive antenna. In particular, it ignored the attenuation of signals transmitted below the main beam and assumed that they would be received at the same level as if they were in the main beam. This assumption overstates the interference contribution of PCS transmitters located on the ground and near the receive antenna tower.

No consideration of interference mitigation

The Comsearch study did not address how a PCS operator could mitigate the harmful effects of PCS operations in the so-called "exclusion zones." Such mitigation techniques would appear to offer substantial potential. A few such techniques come immediately to mind. The PCS system operator could "engineer in" its base stations, providing more attenuation towards the microwave system than was assumed in the Comsearch study. The Comsearch study assumed that base stations transmitted using an omnidirectional pattern. But, of course, this is not necessary. Directional antennas are commonly used in cellular to restrict cell size, to focus coverage, and to control interference. They can be used in a similar fashion to fit base stations into the so-called "exclusion zone." Similarly, base stations could he engineered taking into account terrain and building blockage factors. Microcells or Remote Antenna Devices (RAD) could be used to fill gaps in coverage at extremely low power levels.

Since PCS systems will incorporate automatic power control, the PCS system operator could deploy only low-power cells in the "exclusion zone." Since this would require a higher cell density in the "exclusion zones" than in the rest of the PCS system, this mitigation technique trades off additional investment by the PCS system operator for reduced interference.

Interference mitigation techniques can also be applied at the microwave system. Additional investment in the microwave system can make it more resistant to interference. For example, replacing a standard microwave antenna with a high-performance antenna reduces interfering signals from behind the antenna by about 10 dB. Similarly, analog microwave systems might he upgraded to digital, giving the microwave system user the advantage of digital connectivity, while at the same time increasing the interference rejection capabilities of the microwave system by as much as 20 dB.

These considerations do not begin to address much more sophisticated techniques for interference mitigation such as smart antennas, wideband CDMA with notch filters, and multiple signal detection methods, all of which are likely to become available during PCS deployment.

Conclusion

Examination of the assumptions of the April 1993 Comsearch Study finds many areas where a more refined analysis would significantly reduce the size of the "exclusion zone" Comsearch calculated. The interference it predicts is many tens of dBs higher than would be expected from a carefully engineered PCS system. Most seriously, it used the term "exclusion zone" (a term that was also used by APC) to refer to areas where the PCS system operator would have to more carefully engineer the PCS system to control interference to the microwave system. These are not regions where PCS operations need be excluded.

V The August 1993 Comsearch Study

At the request of Bell Atlantic, Comsearch has prepared a second study of PCS/microwave sharing in Detroit. While Comsearch used the same analytic tools and interference criteria as it had in the April study, Comsearch modified a few key assumptions of the April study. In particular, Comsearch reduced the peak power of the PCS system to bring power levels closer to those expected of PCS technology. Additionally, Comsearch modified its interference calculations to reflect the interference performance of CDMA signals rather than of narrowband digital signals. Comsearch's August calculations did not take into account many of the factors we discussed above such as directionalization of PCS base stations, the 20 or 30 dB disparity between peak and average power, the possibility of interference mitigation at the microwave system, and several other elements. Nevertheless, Comsearch was able to conclude:

> The results of this conservative analysis indicate that the 20 MHz PCS allocation is indeed feasible for deploying a CDMA PCS system.[18]

and

> ... [T]he conservative assumptions used throughout the present analysis present a worse-case approach. Accordingly, the results should only improve as the models and data themselves improve. Results of this future work will be forthcoming.[19]

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[18] Comsearch, "Analysis of a 20 MHz PCS Spectrum Allocation for Detroit" (August 1993) ("August 1993 Comsearch Study"), at 9.

[19] *Id.* at 12.

The implications of more realistic assumptions are striking. Comsearch finds that PCS operation in 20 MHz bands is feasible. We concur with this conclusion and have attached the entire Comsearch study as Appendix A to this report. A comparison of the assumptions used in these studies is given in Table 1 below:

Key Assumptions of the APC and Comsearch Studies

System Attribute	APC	Comsearch (4/93)	Comsearch (8/93)
Peak Mobile Power	1 watt	1 watt	200 milliwatts
Average power effects considered	no	no	no
Propagation model	Hata	Hata, modified for over the horizon	Hata, modified for over the horizon
Microwave system loading	per 10E	per 10E	per 10E
Consideration of microwave system margin	no	no	no
Elevation discrimination in microwave antenna	no	no	no
PCS interference mitigation considered	no	no	no, but discussed
CDMA spreading considered	no	no	yes
Grid edge size	1.25 minutes (approximately 1.25 miles)	ten seconds (approximately one-sixth mile)	ten seconds (approximately one-sixth mile)
Microwave antenna directivity	azimuth only, "typical parameters	azimuth only, actual antenna parameters	azimuth only, actual antenna parameters
PCS cell size	0.25 to 0.5 miles	1.61 km	1.71 km
Microwave system configuration	hypothetical	actual (Detroit)	actual (Detroit)

VI Conclusions

The stakes in PCS are enormous. The FCC is in the process of designing a major new communications service which will affect our nation for decades to come. One contentious issue is the bandwidth required by individual PCS licenses. This report has shown that previous observations on this bandwidth issue were based on studies using tools and parameters

appropriate for other purposes, and that the use of the hyper-conservative parameters produces results biased towards a requirement for larger bandwidths for PCS systems.

Use of the term "exclusion zone," rather than a more informative term such as "careful engineering zone" also biases the discussion against understanding the potential for 20 MHz PCS licenses.

Finally, we offer the August 1993 Comsearch Study, which quantitatively shows the changes in results that flow from adopting some, but not all, of the improvements in analysis we suggest are required for full understanding. That study shows that PCS operations in 20 MHz are feasible.

Based upon our criticisms of the earlier studies and the results of the August 1993 Comsearch Study, we suggest that it would be wrong for the Commission to rely on earlier studies as a basis for an informed conclusion on the proper bandwidth for PCS licenses.